point more than 7 lbs., thus showing the designer, in the clearest way, the proper thickness of brickwork to be used, and at what points to change from one thickness to another.

The consideration of the wind pressure in connection with roofs and bridges must be left for treatment in another paper.

Art. IV.—*Evidences of a Glacial Epoch from Kerguelen's Land, being Comments upon the "Challenger" Reports.*

By Mr. G. S. Griffiths.

[Read 13th May, 1886.]

The occasion of adding to our library two volumes which summarise the labours of the "Challenger" expedition, affords me an opportunity of describing some discoveries in Kerguelen's Land which tend to throw some more light upon the nature of the climate of this hemisphere in the past.

Kerguelen's Land is a small island placed upon an isolated submarine plateau about 450 miles long and 250 miles wide, situated in 49 deg. S., 68 deg. W. Its coast-line is broken on every side by deep sounds, and two ranges of comparatively lofty mountains divide the limited territory between them. The western range has a mean height of about 3400 feet, and an extreme one of 6120 feet. The eastern system has a mean of 3000 feet. The mountains appear to be a series of extinct volcanoes, but the west coast has one still active, and it is surrounded by hot-water springs, petroleum springs, and mineral pitch deposits, all phenomena characteristic of the later stages of expiring vulcanicity. The entire island is built up of horizontal layers of lava, clay, and coal. The lava beds are from 10 to 20 feet in thickness, and these are separated by thinner beds of the other materials named. There are also with these abundant deposits of fossilised pine trees, and some of the trunks of these trees are two feet in diameter. These horizontal strata enwrap the bases of numerous domes and peaks of grey phonolite, an older volcanic rock. This phonolite is also disposed horizontally, and the peaks are but the remnants of more ancient plateaux which had already

been weathered down into so many rugged outliers before the last series of lava outflows had commenced to flow. The sea cliffs, being everywhere built up of hard and soft layers, have weathered into a series of well-marked ledges, which ascend from the beach to the mountain tops in natural staircases.

The island is situated in the path of the wet westerly winds which blow strongly and with few interruptions.

The higher range is also the weather range, and its crests intercept the low-travelling clouds. These snow-capped heights wring from the passing winds their moisture, which is deposited, at the greater altitudes, in snow, and at the lesser in sleet and rain, and the winds then pass on to the lower hills at the eastern and leeward end of the islands, diminished in force and in a comparatively dry and cloudless condition, and in descending they may become relatively warm. In consequence of these circumstances the leeward range, although 3000 feet in mean altitude, is always free from snow in summer; while the weather range, with a mean altitude only 400 feet higher, is covered with perpetual snow, which unloads itself down the valleys in great glaciers. These latter do not anywhere reach the coast, and their terminal faces are but rarely even visible from the sea-shore, owing to the thickness of the atmosphere in their vicinity, and to their distance inland.

The interesting feature in relation to these glaciers, and the one to which I desire more particularly to call your attention, is that, whereas they are to-day confined to the higher valleys of the higher range, there are abundant and indisputable* evidences that the whole island down to, and even below, the sea-level, was buried under ice at a comparatively recent period. The furrows of glaciers are seen wherever the island has been explored. The lower hill-tops, still bare and barren, have been cut down by travelling ice, which has planed them smooth exposing clean-cut, horizontal sections of the geodes of the amygdaloidal rocks. Each shelf of the basalt stairs has its striæ, and the lower valleys are scratched and scraped and smoothed by glaciers which have since disappeared. † Every harbour is an ice-cut fiord. Royal Sound has its entrance barred by a sill but 15 fathoms deep, whereas its floor falls within until, near to

* *Challenger Reports*, p. 348. † *Challenger*, p. 356.

its head, there is a depth of from 70 to 100 fathoms. Its numerous islets are all flat-topped, having been planed down to a common shape and level; and these truncated islets have their surfaces covered with erratics. *

Thus we see that the island presents every indication of its having been more extensively ice covered not long since, and the great changes in the climate of Kerguelen's Land indicated by the existence of forests of fine timber at one time, and by the occurrence of an ice-sheet enveloping the entire island at another, help to confirm the conclusion which has been drawn from the facts of Australian geology that the southern hemisphere has had its secular climatic mutations. Thus a large question at issue is being gradually reduced to the lesser one, of whether the temperature oscillations were local, and due to local causes, or universal in obedience to some less obvious and more cosmic influences.

There are some other interesting features connected with this island.

The flora of the island is poor. The ranker vegetation dies out at an altitude of 300 feet, but flowering plants cover the hill sides up to 1000 feet, and they exist in patches where there is shelter up to 1300 feet.

Under the protection of the herbage a few species of inactive, wingless flies, gnats, and moths crawl, their habits and structural modification exhibiting an interesting relation to their small, isolated, and boisterous habitat. The higher fauna is restricted to birds and seals. The climate is typically insular, with the small annual range of 9 degs., the mean summer temperature being about 45° F., and the winter 36° F. Even in the depth of winter the thermometer at the sea-level rarely falls below the freezing point, and the snow never lies on the low ground for longer than two or three days.†

When we remember that the weather range is perpetually snow-covered at a small altitude, and that Heard Island, but three hundred miles to the southwards, is glacier-covered to the water's edge, we must be struck with the circumstance that the Kerguelen vegetation is perennial, and not annual, and that it is not only evergreen, but that some of its plants were observed by Ross to be in flower at midwinter.‡

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* *Challenger*, 332; *Ross*, Vol. I., p. 69. † *Challenger Reports*, 354.

‡ *Ross*, Vol. 1., p. 86, and *Challenger Reports*, p. 355.

There are some other interesting generalisations to be noted in connection with the "Challenger's" Antarctic trip. It is believed that in winter the sea to the south of 63° is frozen over.* At all seasons of the year a thin wedge-shaped layer of ice-cold water projects northwards to 54 deg. south, covered by a skin of warmer water. The thickness of a single season's ice is believed to be about three feet,† whereas in the Arctic it is six feet. The icebergs are stratified horizontally, the oldest and lowest strata being the thinnest, as the result of vertical compression and horizontal expansion. But the ice possesses a fine cleavage lamination,‡ the faces of which lie at right angles to the bedding. The enormous outward thrust operating from the pole, squeezing the ice-sheet outwards at the rate of a quarter of a mile per annum, will account for the cleavage, and its occurrence under such circumstances affords geologists a striking confirmation of the correctness of the theory which has been advanced to explain rock cleavage.

Two important features of the Antarctic Ocean have been brought to light.

Firstly, the nature of the sea-bed changes as we go southwards. It is barred with different materials, which, disposed in three concentric zones, encircle the polar regions, and, similarly, the ocean water is banded with three distinct micro-faunal regions, corresponding in their respective positions with the series of deposits accumulating below. Between 64 deg. and 66 deg. S. we have the blue muds, with pebbles and decomposed shales, which elsewhere always indicate land proximity. In this deposit, then, we have an unexpected testimony to the existence of a land area around the Antarctic Pole. From 64 deg. to 53 deg. S. the bottom consists of diatom ooze and a little mineral matter derived from the overlying ocean, which supports enormous swarms of diatoms and a smaller number of radiolarians.

From 53 deg. to 47 deg. S globigerina ooze predominates, and north of 47 deg. south red clay with such deep-sea deposits of whales' ear-bones, sharks' teeth, and manganese nodules, as are indicative of clear still water.§

Singular testimony to a past cold epoch was found at two stations in 38 deg. S, within the Pacific, in the shape of small granite erratics found far from land. ‖

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* Rep. p. 418. † Rep. p. 430. ‡ Rep. 432.

§ *Challenger Reports*, p. 813. ‖ *Reports*, p. 435.

These erratics could have reached these localities only by iceberg transport, and excepting during a cold epoch icebergs would be melted long before they could approach so near to the equator.

The expedition noted as did Ross that icebergs were very scarce to the west of 80 deg. E, and from this circumstance they judged that much Antarctic land did not exist on that meridian. This should indicate the course for the forthcoming south polar expedition to take.* And in connection with Antarctic expedition the small downward range of the thermometer at Kerguelen warrants us in hoping that the Antarctic climate is milder and less trying to explorers than that of the Arctic. Though the summer be chillier than that of the north, the winter is less severe. A self-registering thermometer exposed for three seasons in the Georgias never sank below —5°

At the Horn the winter temperature is very little lower than that of Greenwich, although the summer temperature is much lower, while the mean range is much less.†

Having added to our library these valuable volumes of the "Challenger" Reports, it appeared to me that the members of this Society might be interested enough in the undertaking to care to listen to these rough memoranda relating to a part of the cruise.

Art. V.—*Plants collected in Capricornic Western Australia, by H. S. King, Esq., and recorded by Baron Von Mueller, K.C.M.G., M. & Ph.D., F.R.S.*

[Read 13th May, 1886.]

During the last year survey-operations were carried on between the Lyons- and Fortescue-Rivers, as well as on and near the Upper Ashburton-River, by Mr. H. S. King, under the direction of the Honourable John Forrest, C.M.G., F.L.S., F.R.G.S.; and on this occasion again, through the influence of the enlightened Minister of Lands and Surveyor-General of the colony, specimens of the plants, met

* *Report*, p. 430; M'Cormack's *Antarctic Voyage*, Vol. 1, p. 166.
† *Challenger Reports*, p. 877.